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14. ABSTRACT

Pairs of platinum mesh or graphite fiber electrodes, one embedded in marine sediment (anode), the other in proximal seawater (cathode), have been used to harvest low levels of power from natural, microbe established, voltage gradients at marine sediment-seawater interfaces. The sustained power harvested has been on the order of 0.01 W/m^2 of electrode geometric area but is dependent on electrode design, sediment composition, and temperature. It is proposed that the sediment/anode - seawater/cathode configuration constitutes a microbial fuel cell in which power results from the net oxidation of sediment organic matter by dissolved seawater oxygen.

15. SUBJECT TERMS

marine sediment, fuel cell, electrode, redox potential, microbial

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Final Report

GRANT #: N00014-98-1-0690

PRINCIPAL INVESTIGATOR: Clare E. Reimers

INSTITUTION: Rutgers, The State University of New Jersey

GRANT TITLE: Harvesting Energy from Redox Potential Gradients in Sediments and Soils

AWARD PERIOD: 1 May 1998 - 31 December 1999

OBJECTIVE: To harvest on the order of 1 Watt of electrical power from depth-dependent potential gradients in natural marine sediments and saturated soils; to use this energy source to continuously power small, unattended, sensor systems in remote environments.

APPROACH: Pairs of platinum mesh or graphite fiber electrodes were placed across sediment-seawater interfaces created in laboratory aquaria. After an equilibration time of a few days, voltages and currents sustained by these two-electrode devices under variable loads were monitored for experimental periods ranging from minutes to months. The sediments and the circulating aerated overlying seawater were electrochemically characterized by profiling (adjacent to the devices) with Pt-redox, voltammetric and pH microelectrodes and sampled with 7.5 cm diameter core tubes. The cored sediments were sectioned into vertical intervals of 0.25-0.5 cm under N_2, and the pore waters extracted for chemical analyses of a number of reduced species such as sulfide and ammonia.

ACCOMPLISHMENTS: The amount of sustainable power harvested during the experiments of this grant period was ~0.01 W/m^2 of electrode geometric area. However this power was found to be dependent on electrode design, sediment composition and temperature. A working model for the observed power generation proposes that two electrode cells, straddling the sediment-seawater interface, depend on a net oxidation of sediment organic matter by dissolved seawater oxygen. Further, half-cell reactions may be catalyzed by sediment microbes and mediated by one or more secondary electron-transfer mediator (such as dissolved sulfide in the sediment pore water).

CONCLUSIONS: The concept of harvesting power from a fuel-cell device at the sediment-seawater interface has been proven in the laboratory. Ongoing investigations will focus on identifying electrode reactions, understanding microbial involvement, optimizing electrodes with respect to power density, and examining prototype devices interfaced with environmental sensors in natural marine settings.

SIGNIFICANCE: Our studies have demonstrated that low levels of power can be harvested from natural, microbe established, voltage gradients at marine sediment-seawater interfaces. Optimized power supplies based on this phenomenon could be developed to power autonomous marine-deployed instrumentation such as hydrophones and chemical sensors.

PATENT INFORMATION: A patent application related to using two electrode devices to harvest power from seafloor potential gradients has been filed.

PUBLICATIONS AND ABSTRACTS:

Reimers, C.E. and Tender, L. M. (1999) A fuel cell for harvesting power from the marine sediment-water interface. EOS 80(49), OS76.

Tender, L.M., **Reimers, C.E.**, Fertig, S. and Wang, W. (2000) Harvesting energy from natural benthic voltage gradients. 198th meeting of the Electrochemical Society, Phoenix, AZ.

Reimers, C.E., Tender, L.M., Fertig, S., and Wang, W. (2001) Harvesting energy from the marine sediment-water interface. Environ. Sci. Technol. 35, 192-195.